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Barriers in running construction SME – case study on introduction of agile methodology to electrical subcontractor

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Abstract

The article presents agile management approach to manage the construction process, which is based on management of IT projects and ideas to improve quality. Initially focused on the application during the implementation of IT project, works were aimed to adjust to changing customer requirements. The main idea of agile in the presented approach to adapt to the changes instead of strict implementation of the plan. The idea of introducing agile management in the construction industry, exemplified with SME company electrical subcontractor, for which the most important problems and barriers of doing business were discussed, is presented in the paper. On the basis of the research, authors proposed solutions and methods in accordance with the agile idea.

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Keywords: flexibility in construction; agile approach; construction process; FMEA analysis; electrical contractor

Nomenclature

RPN	Risk Priority Number
P	Probability
W	Detection

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1. Introduction

The desire to seek new solutions in the field of management of the building processes results from the complicated situation in the construction sector compared to other areas of economic activity. In construction, the production has different characteristics, which is caused by two main reasons:

- Instability of the production processes (production is unique and has action nature of construction projects are different).
- Changing environment influences, from which it is difficult to be independent.

Action nature of production on the one hand causes problems with the necessity of implementation of tasks at the maximum level resources in the company, on the other - the risk of not using its potential due to a lack of orders. Turbulently changing environment requires solutions connected with a change of plan rapidly and with limited cost. It also often requires the preparation of various technological options, the use of which is dependent on difficult to predict performance conditions (e.g.: temperature during concreting).

Traditional management under one plan for the entire project works only in exceptional circumstances. Meanwhile, prediction of the situation in the near future (even weather forecast for 48 hours) is burdened with considerable risks. Interference may result from a variety of sources (investor, designer, general contractor, supplier, subcontractor, external factors, etc.). The specific problems of construction sites include: budged overrun, missed deadlines and quality deficiencies. Overrun, in this respect at the level about 30-50% are quite common, but some examples (Sydney Opera House [1], airport in Berlin [2]) indicate the possibility of exceeding both the deadline and budget even several times. A significant discrepancy in construction is a priority for action of contractor (maximizing the effectiveness of use of resources) and the investor / user (value in use throughout the life cycle of a building). Described problems can have different sources:

- Bidding: using price as a key criterion in the awarding of contracts in construction,
- Client: payment delay, delayed decisions, changing requirements,
- Consultant: delayed decision,
- Designer: incomplete documentation or documentation errors,
- Workforce: lack of qualifications, lack of motivation,
- General contractor: faulty planning and scheduling,
- Material: wrong type and amount of materials,
- Supplier: late delivery, wrong delivery, non-delivery,
- Contract agreement: short term, unfavorable conditions for one of the parties, loopholes in the agreement,
- Environment: the weather, the ground water level,
- Force majeure: flood, earthquake, acts of terror.

These reasons have led to many disputes: the use of the occasion, suspend the execution of the contract, changes in shareholders' project; which for SMEs operating in the construction industry could mean serious distortions in the functioning. For SME basic construction problems arise from the need to cooperate with economically much larger partners and, already mentioned, project nature of construction activities.

In contrast, an important element of the SME advantage is the possibility of systematically learning through a relatively narrow specialization - gathering knowledge of ongoing work (e.g. the exercise of concrete structures, installation, finishing works at repetitive stories, implementing the typical installations) or learning from already completed similar works (called case based learning, learning by doing). Flexibility is understood in this case as an opportunity to adapt to changing external conditions(e.g. Weather conditions) and internal conditions (e.g. Employee absences). Clearly, there is considerable dependence on the effectiveness and efficiency of SMEs in the construction of cooperation with the designer, general contractor, investor and suppliers. The activities of small autonomous construction company allows to use opportunities arising from the different from hierarchical, in large companies,

structure of the enterprise (flat structure, employee participation in decision-making and bearing any responsibility for them) that allowed the Japanese to gain advantage in the field of quality management.

In the described situation important skill is to maintain the right balance between available resources and the adopted order (works to perform) and the execution of works in a way that ensures the progress of the works - in accordance with the originally established schedule - despite the difficulties. It must be assumed that difficulties in different forms (e.g. delays in deliveries, design errors, hardware failures) will occur. And even when they do not relate directly to the operation of the project, it can be expected that problem will be transferred into this field because of interdependencies (which are visible in the network model). If they end up on the critical path network model, it is clear that only the appropriate intervention to compensate this delay may lead to completion of execution of the works successfully. This effect can be achieved by using flexible or agile approach in management.

The purpose of this article is to present the possibility of using agile management in the SME in the construction industry based on the example of electrical subcontractor. Using the experience in introducing flexibility in typical production systems, possibilities to improve construction process should be considered using the flexibility and agility ideas. In the presented terms agility means higher form of flexibility based on close contacts with the client and stand-alone teams allowing adapting quickly to sudden change in processes in progress or environment. Described concept is one of the directions of change in the field of construction management, which is based on the evolution of the economy in the early 21st century. These changes have led to modifications in management paradigms, and critical success factors in the operating companies.

Article describes also actions to counteract problems related to the entire construction industry, taking into account the special role of small and medium sized construction companies, functioning normally as subcontractors in the structure of construction projects.

2. Agile management idea

It should be emphasized that the achievements concerning the application of the agile management in the field of construction is not extensive [3, 4, 5], but assuming that agile is associated with the use of flexibility which having its origins in the economy [6]. Initiated by Halpin [7] and currently undertaken with regard to the construction industry [8,9,10,12,18] agile is mainly aimed at fighting with common problems in the design, implementation and subsequent operation of construction projects, consisting primarily of exceeded budget, deadline for completion, low quality, difficulty in predicting interference and demand. Application of flexibility overcomes these problems by:

- The use of staging in investments in order to adapt to unforeseeable changes in demand [10].
- Phasing decisions making, taking into account not only the present state, but also the unknown prospects of development taking into account the evaluation in accordance with the objectives of sustainable construction [9].
- Execution of construction processes despite of interference in adapting realization methods to the expected or detected environment [8].
- The application of reduction list of options to ensure the implementation of construction projects at the level provided for the total costs, in spite of changes in sub-tasks [1].

In order to solve these kind of problems specific methods proposed in construction engineering and management can be noted: risk management using utility theory [21], process notation and assessment [22], selecting of supply sources for given process [23], synchronization of the manufacturing process and on-site installation [24], knowledge supplementation [13]. These methods could support the introduction of the concept based on flexibility.

As milestones in the development of the agile concept can be considered: development of Toyota Production System (1988) [13], Lean with respect to construction (1992), development of a SCRUM method (1995), presentation of Last Planner System (2000) [15] and Agile Manifesto (2001) [16]. Considering the limited number of studies on the agile applications in the construction industry seems reasonable to adopt approach according to a recently published report on the application of the agile as a competence in project management team [3], which is based on the following assumptions:

- Agility should be seen as a skill, not a method of action. Developing "agile" as competence should be based on their own approach. It is difficult to present prescription for its development.
- Agility is critical in case of innovative projects. At least 37.8% of the projects that use traditional practices were considered to be "more agile" because of the use of certain elements considered to be agile management practices. This is proof that, consciously or not, these teams have developed a certain level of agility having to deal with constant changes or leading innovative projects in the organization.
- Flexibility is a key element of agility. It is difficult to implement changes without having appropriate level of flexibility. In a dynamically changing environment (especially for innovative product development) changes are expected and perceived positively. The project team and the organization must understand that changes will occur frequently, and you have to be ready to respond to them appropriately. Accordingly, the ability to learn and rapid response to changes are necessary to be more flexible. Appropriate risk management and change in management of processes are very helpful for improving flexibility and anticipation of changes and potential opportunities.
- The maximum simplification is the "mantra" for the team. One of the key aspects of the introduction of flexibility is to act in terms of processes, practices and tools in the least complicated way. Using the tools to visualize (i.e. tables, drawings, etc.), combined with frequent mutual contacts (and meetings of an informal nature) directing the project, will help the team maintain a clear vision of the whole process and responsibly plan and implement it. In some projects of high complexity solution would have to be taken on different levels of planning and control using various tools and techniques.
- Promotion of the autonomy and independence of behavior among members of project team is necessary. These are key skills in order to use simpler and more flexible management approaches. Team members should be actively involved in the development and decision-making and should be responsible and co-responsible for planning and monitoring activities.
- Finding own procedure. The level of diversity of the portfolio of activities is rapidly increasing in many organizations. Developing a "hybrid approach" consisting of different sets of practices, tools and techniques and team competence will help organizations succeed in various contexts of its activities.

An important message of the report, recently developed by a group of the Consortium for Engineering Excellence Program (CEPE) under the direction of Conforto at MIT, is to determine the importance of the need for the agile approach due to changes in the economy merging with the rapid change of technology, customers demanding innovation and uncertainty in economic activity. Although, the introduction in the previous decade of agile management is uniquely associated with Agile Manifesto (and the sector of computer science), but - as shown by mentioned report - it now also applies to sectors of the economy, such as: consulting, financial services, insurance companies and telecommunications. It seems that the prospects for the use of the agile management should be connected with a hybrid approach, based on the whole range of tools that must be skillfully adapted to the specifics (systemic and situational approach).

Basing on above assumptions, the agile management can be defined as the ability to adjust founded on the flexibility methodologies to adapt to expected or unexpected changes quickly (in the shortest possible time), using autonomous work teams, capable of systematic updating of knowledge (learning), based on the continuous contact with other stakeholders. Comparing the definitions of flexibility and agility (assuming flexibility as a willingness to make changes) it can be concluded that a more agile refers to rapid change based on the option switch, which can be referred in particular to the operation level (changing technological and organizational options in response to changing circumstances in construction processes). It relates to the idea of flexibility built into the process, which refers to the idea of changing function. The second is the flexibility of the idea which consists of taking into account the flexibility in design (and leaving options for implementation - open) [8]. Comparison of traditional management and agile management is presented in Table 1.

On the background of these differences, the basic places of the introduction of agile approaches in construction can be determined:

- Operation in a dynamically changing environment,
- Promotion of public construction contracts in the design and build system, [11]

- Rapid dissemination of the idea of intelligent building, demanding control installation and the construction and operation management system (activation period often exceeds the period of construction),
- New possibilities for the collection, transmission and processing of information,
- Dynamic development of decision support systems (expert systems),
- Rapid technological development (shorten product life cycles),
- Application of quality assurance systems often leads to excessive rigidity (restrictions adaptation to change - passive attitude towards innovation and limit the creativity of employees).

Table 1. Traditional and agile management comparison [based on:16, 19, 20]

Factor	Traditional approach	Agile management
Goal	The efficiency and effectiveness	Development in cooperation with customer
Action	Sequence of tasks	Iterative (loop)
Basic advantage	The hierarchy from top to bottom	Independent teams
Change management	Deviation from the plan - the negative risk	Chance to improve the quality and increase satisfaction
Knowledge development	Recording in a knowledge management system	Iterative learning process- improve within the same project
Realization Strategy	The entire project from start to final acceptance	The division into small tasks (fragmentation)
Information Transfer	Official ~~year~~ - according to the hierarchy	Verbal - based on personal contacts (to cooperate)
Amount of options	Single	Multiple

Analyzing the current use of agile management in the construction industry, the essential features of traditional project management must take into account (in which the subject of management shall be buildings as physical objects as opposed to a focus on services based on designing and commissioning systems), whose share in the construction industry far outweighs applications in IT. Hence, it is proposed a hybrid approach in which both approaches are applicable in relation to each relevant elements project. According to authors shared agile management idea will grow in proportion to the increasing involvement of information technology in construction industry.

3. Case study

For the purposes of this article entrepreneur was interviewed concerning major, issues and barriers to doing business in the region of Wielkopolska, Poland. Created Ishikawa diagram (Fig. 1) is showing received information. In the following section of article, various branches of the diagram presenting problems will be discussed in detail.

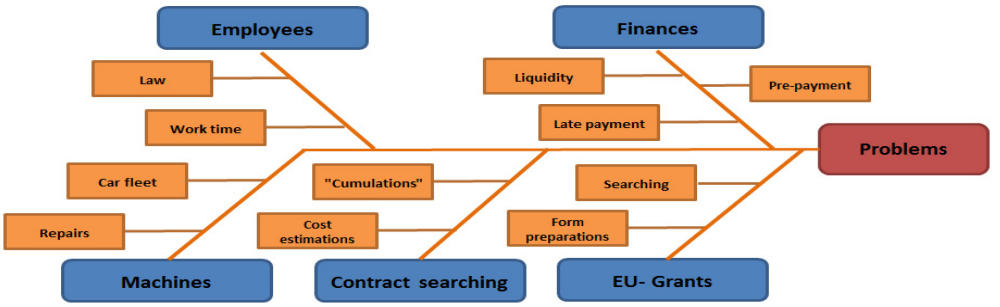

Fig. 1. Ishikawa diagram of typical problems of small electrical company.

3.1. Company description

The company was founded in 1992 in Poznan. It operates in Wielkopolska province, mainly in the city of Poznań. In the company, except from the owner coordinating the works, 4 people are employed on full-time conditions - skilled workers performing work related to the laying of cables and performing electrical measurements. In addition, if necessary, the company employs temporary workers for the execution of extra orders.

Initially the company was engaged in the performance of general construction works, however, seeing a chance in specialization its services, owner decided to execute mainly logical and electrical installations. The main ventures are works as a subcontractor electrical work in hospital buildings in the city of Poznan and the area Wielkopolska province. Work on the modernization and construction of medical units has become the main source of income of the enterprise. Currently the company due to the problems affecting the entire construction industry is looking for cost savings and new opportunities in the construction market.

3.2. Key issues and barriers in running business

A key aspect of doing business for small companies are finances defined as finance liquidity. In the present reality each subcontractor is required to provide necessary materials and to execute all the orders without receiving pre-payment. In addition, the standard deadline for payment for contract is set at 30 days after the end of the order, where in 70% of cases this term are considerably exceeded. It was found that on average, for 10 made in a timely manner and without significant errors contracts in 2012, there were 7 delayed payments up to three months after the deadline for payment. In such a situation there exists obvious problem of financial liquidity and performance of the entrepreneur in preparation and taking future works. Although the owner has opened a credit line for such situations, when there is high congestion of late payments, it is not sufficient.

Each, especially small entrepreneurship, is formed by its workers. They play special role in small companies, where experienced professionals become indispensable, and possible resignations from work by these workers cause a disturbance situation throughout the company. Very big problem in carrying out projects becomes time of work shifts. From the employee's perspective works should be performed at fixed hours of the day, in a 40-hour work week. Unfortunately, in the case of orders with short lead times, the employer is forced to extend employee working time. It is not always accepted with satisfaction by the employees, often causing tensions. On the other hand, in the reverse situation, namely lack of orders and turning business activity to "slow motion" employer would send workers on forced leave, because there is no work for them and their time is wasted.

The main problem here are legal solutions and the fact that working week is stiffed instead of being more flexible, which makes activities based on the performance of work on commission a big challenge at extreme moments - lots and a lack of orders. Employees knowing perfectly the law enforce the rules with his attitude additional remuneration for the period beyond the statutory 40-hours week of work, while not acknowledging and agreeing to the potential rate reductions in the absence of orders.

Searching for contracts is a key activity involved with the owner. Without finding and submission of tenders it is impossible to stay in business, especially in the current economic downturn. Particularly in construction, it can be encountered issue called "accumulation" of orders. It has been observed that if there is no contract it is very hard to find and get them, thus there is no work for the employees and the company does not make profit. However, in the case where winning tenders is successful, it is usually not only one but several at the same time. In this kind of situation there is often need to select the works most cost/profit-effective, feasible and reject others, which also potentially could be realized. It happens that orders are entered in reserve for fear of stagnation, according to the principal of "working more is better than not working at all".

An indissoluble aspect of searching for contracts is preparation of cost estimates and price bids. It is obvious that without relevant experience and knowledge of the prices of materials and labor in a given region is not possible to prepare the offer. Frequent are the situations when to win in a 1 tender offer a dozen different offers has to be prepare and sent. The ratio of rejected offers to winnings is low. With conducting research it was established that on average 2 to 10 prepared tenders manages to be successful. It turns out that crucial, from the point of view of the company, and most time-consuming work is preparing an offer which is also the least efficient in the whole job. In

the current circumstances it is very difficult to change this situation, due to the very high competition on the market, where customer can pick up easily other contractors and subcontractors.

The equipment is a necessary means to carry out described operations. It should be distinguished the two categories of it: light equipment, and transport vehicles which are used in the enterprise. With several employees base of light equipment proves to be necessary taking into account the reserve ready for use in case of emergency. Problematic is the moment when working on two contracts, equipment must be transported with employees in two or more points.

The company in the current situation owns one company vehicle van used to transport the necessary materials to construction sites. Workers are using their own means of transport. The company should purchase additional vehicles that will enable the movement of workers between construction sites during the day quickly. Currently the situation related to the use of private cars during operation is complicated and expensive, since workers must be allowance for each kilometer traveled by private car at work. They awaited solution would be to purchase an additional vehicle to transport people. Unfortunately, the economic situation the company does not allow for such a purchase, and the problem is causing growing frustration of workers who, in their opinion, make a contribution to work using their own vehicles.

EU grants are also very actual topic for the company, as for the analyzed entrepreneur it is one of the important issues that inhibits its growth. The basic problem is the lack of time management and finding the time to analyze needs and prepare an application for funding. Current regulations and requirements of the EU are a big difficulty and without the assistance of a costly professional and very hard to get EU support, e.g. for the purchase of vehicles to the company. It is a calamity, which is struggling entrepreneur for a long time. Having many tasks associated with the watch of the currently executing contracts and preparing bids for new work, there is simply lack of the time not only to write down the grant request, but find which program company could apply for funds.

3.3. FMEA Analysis

All the problems and barriers were analyzed in terms of probability of occurrence, ease of detection and the importance and impact on the functioning of the entire company. The RPN factor was calculated using formula (1). The results are presented in Table 2. The higher the RPN is the more important issue is for the company.

$$RPN = P \cdot W \cdot Z \tag{1}$$

The analysis shows that the key issues in the enterprise are: delay of terms of remuneration (RPN = 700), "the accumulation contracts" (RPN = 378) illiquidity (RPN = 360) and working time (RPN = 343). The least important problem proved to be too small number of vehicles (RPN = 24) and no pre-payments (RPN = 45).

The proposed solution in most cases is effective remedies to the problems of entrepreneurs. The lowest effectiveness is lobbying for changes favorable for the persons running the company, because alone very hard to convince officials / MPs to change the law. This also follows a lot of money that small businesses do not have. The highest efficiency can be seen at issue "commutation".

3.4. Agile Switch

The high effectiveness in presented solutions is due to the flexible approach in the planning and implementation of a large number of orders which failed to implement by proposing a work scheduling and the ability to instantly switch between works, in case of problems and downtime.

In the table 3 and 4 basic information about needed work-load for orders is presented, on the basis of which a decision was made to extend the day shift for employees.

As seen from above, at the moment in which the owner is not able to recruit more staff, the only way to finish all the contracts within deadlines, was to increase the length of change from eight to ten hours a day and lengthening the work week to six days. Applied operation can be assessed as a flexible approach in planning the load for workers. Of course, in return for increased load employed persons must receive appropriate, additional gratification,

but in the final analysis, the entrepreneur is able to execute orders within a period of not paying contractual penalties and earn all 3 orders.

Table 2. FMEA

Problem		Probability	Detection	Severity	RPN	Solution	% of solved issues
Finances	Liquidity	**4**	**9**	**10**	**360**	-Agile adoption and planning contracts -Obtaining the credit line	70%
	Late payments	**7**	**10**	**10**	**700**	-Use the services of debt collection companies -Provisions in agreements on partial pay after the completion of the phase of work	80%
	Pre-payments	**9**	**1**	**5**	**45**	-Taking loans to service contracts without advance payments -Phasing of investments and settlements	50%
Employ-ees	Law	**5**	**2**	**5**	**50**	-Lobbying for changes favorable for entrepreneurs	10%
	Work time	**7**	**7**	**7**	**343**	-A low basic wage and well-paid overtime -Flexible work time	70%
Machines	Repairs	**4**	**8**	**5**	**160**	-The purchase of equipment with guarantee -Purchase of spare equipment	70%
	Car fleet	**4**	**2**	**3**	**24**	-Purchase of cheap means of transport -Hire a vehicle in critical moments	50%
Contract searching	Cumulating	**6**	**9**	**7**	**378**	-The use of agility in searching -Flexible approach to planning and implementing a large number of orders	90%
	Cost Estimations	**7**	**3**	**7**	**147**	-Employment of cost estimator -Outsourcing services, cost estimates	60%
	Searching	**5**	**3**	**6**	**90**	-Outsourcing exploration services	80%
EU grants	Form preparations	**8**	**2**	**8**	**128**	-Outsourcing of preparatory writing applications	80%
		1-Never	1-Easy	1-Small			
		10-Always	10-Hard	10-Huge			

Table 3. Statement of effort required for execution of individual contracts

	Deadline (days)	the amount of work required for 2-person teams [hours]
Contract 1	180	700
Contract 2	120	930
Contract 3	180	1400
	Sum	3030

Table 4. Statement of the maximum number of hours in the distinction between works in five- and six-day working week

The maximum possible number of hours to be worked for 2 teams for 6 months [h]	
5-day working week (24 weekdays per month), 8-hour shift	2304
5-day working week (24 weekdays per month), 10-hour shift	2880
6-day working week (26 weekdays per month), 8-hour shift	2496
6-day working week (26 weekdays per month),10-hour shift	3120

With the introduction of agile project management principles it was also possible to quickly switch between teams when the disturbance occurred on one or more of construction sites. The situation and the moment in which switching tactics can be used are presented in the schedule. (Fig.2a. and 2b.)

The creation of this type of schedule allowed planning ahead of time to work on contracts and enabled remedial measures, in the form of changing load variations for employees. In addition, the effect of occurrence of other unforeseen situations related to the accepted contract followed by rapid reallocation of resources between the orders, which means that employees were ensured constantly and was independent of momentary stoppages on the site, is minimized. It should be noted that agile switch between construction sites is possible only if we work together on several (at least 2 to 2 brigades construction work)

A similar tactic associated with the lengthening of working hours and agile switching can be successfully used in the implementation of other construction work on simple processes. Of course, each case should be examined whether the mode of operation is profitable for the company and how it affects employee morale, as it may turn out that without adequate financial incentives work efficiency will drop overtime and extended hours do not became a shorter deadline of completion of works.

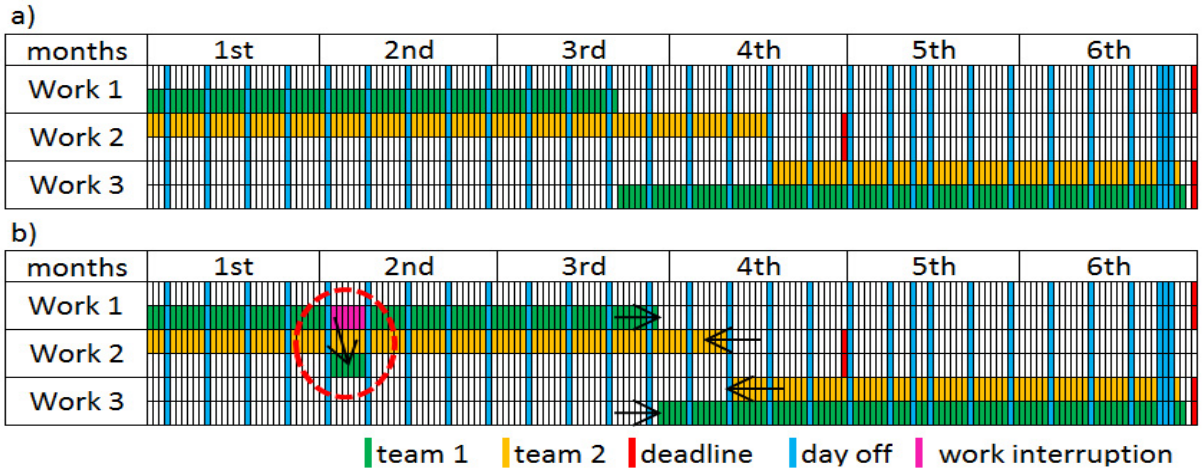

Fig. 2. (a) Flexible schedule of 6 day working week and 10h shift.; (b) Agile schedule with switch example for work interruption

4. Conclusions

Considering introduction of agile approach in case study on the electrical contractor of SME type regarding problems and barriers in running business in Poland the following conclusions can be made:

- Agile as an approach in Construction Management is based on flexible management capabilities resulting from the switch between implemented in parallel ventures (projects).
- When considering the possibility of introducing Agile Management it should be indicated the typical sequence: first, the introduction of the Quality Assurance procedures, then TQM, then the Flexible Management in both options: flexibility in the project and between projects (hard to see the type of restrictions: first, flexibility in a single project later in between).
- IT techniques with emphasis on mobile technology play a key role in agile management capabilities - proactive management based on the data on-line.
- It seems that the typical small construction industry businesses should have the possibility to introduce Agile Management through the implementation of several projects simultaneously.
- Proposed methodology is a good solution for problems analysis and solution finding in the construction industry for SME companies.

Naturally, these ideas do not exhaust all possibilities of application of the idea of Flexible Management and Agile Manufacturing. An important element for the proposed methodologies is the increased adoption design and builds contracts and the increasing importance of construction management systems implemented as IT projects. The authors seek further opportunities to use agile approach in the construction industry, which as a field of economy is characterized by a fairly considerable specificity (diversity).

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